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ROBERT RECORDE

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Robert Recorde is the morning star of English mathematical literature, the first writer of note to use the English language as the vehicle of thought in arithmetic, algebra and geometry. Nor were his intellectual interests confined to mathematics; he wrote on medicine and, it is said, was physician to Edward VI and Queen Mary. He and the astrologer John Dee were among the very earliest in England to adopt the Copernican system. In the Latin language mathematical texts of note had appeared somewhat earlier in England. Bishop Tonnstall's classic work on arithmetic, the *De Arte Supputandi*, bears the date of 1522; Recorde's arithmetic, *The Grovnd of Artes*, appeared about twenty years later. As regards geometry, De Morgan states that Bishop Robert Greathead's *Compendium Sphaerae* was published in 1531. Recorde's geometry, entitled *The Pathway to Knowledg*, was printed in 1551 and antedated Billingsley's famous English edition of Euclid's *Elements* by nineteen years. But Recorde's algebra, *The Whetstone of Witte*, has no forerunners in England in any language.

Of the three books of Recorde which we have mentioned, *The Grovnd of Artes* enjoyed by far the widest circulation. The date of the first edition is uncertain, but falls somewhere in the interval 1540 to 1543. The oldest edition in the British Museum bears the date 1543; that copy gives no evidence of the existence of an earlier edition. If *The Ground of Artes* (as the title was printed in 1543) did appear some time in 1540-1542, then it is surprising that a new edition should be called for as early as 1543. The edition next following that of 1543 is dated 1549. As long as no copy of an edition antedating 1543 can be found anywhere, the probability is that this is the earliest. During the sixteenth century there appeared a dozen or more editions. After Recorde's death, the book was augmented by John Dee, later by John Mellis, Robert Norton, Robert Hartwell, Thomas Willsford and Edward Hatton. An edition by Hatton bears the date 1699. The book held its place in schools for over 150 years. Recorde's other books enjoyed no such popularity. His *Pathway to*

Knowledg passed through three editions, his *Whetstone of Witte* failed to reach a second edition.

The *Whetstone of Witte* was published in London shortly before the author's death in 1558.* His "Dedicatorie" of this work is dated "At London the .XII. daie of Nouember, 1557." At the end of the book the explanation of "vniversalle rootes" or the roots of binomials of the form $a + \sqrt{b^2}$ is interrupted by the Master's words:

"But harke, what meaneth that hastie knockyng at the doore:
Scholar. It is a messenger.

Master. What is the message; tel me in mine eare. Yea Sir is that the matter? Then is there noe remedie, but that I must neglect all studies, and teaching, for to withstande those daungers. My fortune is not so good, to haue quiete tyme to teache. . . . I mighte haue been quietly permitted, to reste but a little lōger."

His reference to his "fortune" suggests financial embarrassments; this much is certain, he died the year following in the King's bench prison at Southwark. The usual assertion that he was imprisoned for debt is rendered doubtful by the fact that in his will of June 28, 1558, he left a little money to his mother and brother and to his officers and fellow prisoners. In his will he styles himself, "Robert Recorde, doctor of physicke, though sicke in body yet whole of mynde." Recorde is not the only mathematician said to have been imprisoned for debt. His Italian contemporary, Hieronimo Cardan, likewise a mathematician and physician, shared this fate.

Writing on geometry, algebra and astronomy in the English language necessitated the introduction of English technical terms for those sciences. Recorde's first publication in geometry, his *Pathway to Knowledg*, 1551, is particularly interesting on this point. On a leaflet, dated May 20, 1665, Isaac Newton says he used "pricked letters" to denote fluxions. To us "pricked" suggests "pierced" or "stung," but not to Newton or Recorde. "A Poynt or a Prycke," says Recorde in his *Pathway to Knowledg* "is named of Geometricians that

* Readers interested in early mathematics in England may consult A. DeMorgan's valuable article, "Notices of English Mathematical and Astronomical Writers between the Norman Conquest and the Year 1600" in the *Companion to the British Almanac* for 1837, pp. 21-44.

small and vnsensible shape, whiche hath in it no partes." A circle "hath in the middell of it a pricke or centre." Recorde's Saxon-English "sharpe" and "blunt" angles or "corners" are no less desirable than our Latin "acute" and "obtuse" angles. His "paralleles, or gemowe lynes" are "suche lines as be drawen foorth still in one distaunce, and are no nerer in one place then in an other." "Gemowe lynes" need not be straight; they may be "tortuouse paralleles," like the letters SS. This notion of "tortuouse paralleles" led Recorde to make the following criticism: "Here might I note the error of good Albert Durer, which affirmeth that no perpendicular lines can be paralleles." True to his Anglo-Saxon, Recorde calls a tangent line a "touche lyne," vertical angles "matche corners." An equilateral triangle he calls a "threlike," an isosceles one, "tweylike." Then follow "quadrangles, which are figures of iiij. corners and of iiij. lines also." His "square quadrate" is what we now term a "square;" his "long square" is our rectangle, his "losenges or diamondes" are our "rhombs," his "losengelike" or "diamōdlike" is our "oblique parallelogram." Parallelograms which are either right or oblique, are designated by the oddly sounding name of "likejammys." One of Recorde's constructions is "to make a likeiāme equall to a triangle appointed, and that in a right lined āgle limited" (*i. e.*, to construct a parallelogram equal to a given triangle and having a prescribed angle). Trapeziums are called "borde formes, they have no syde equall to an other."

Pentagons, hexagons and heptagons are called "cinkangles," "siseangles" and "septangles." Certainly a "plumme line" is preferable to our "perpendicular line."

One reason why Recorde's terminology did not find adoption, may be inferred from the fact that for over a century after his day, the language of scholars continued to be Latin and the more important and influential mathematical works were mostly in Latin. Of William Oughtred's *Clavis Mathematicae*, which appeared during the 17th century in seven editions, five were in Latin and only two in English. John Wallis' *Algebra* of 1685, was in 1693 translated by him from English into Latin. With Latin as the dominating language, there was little opportunity

for Saxon-English technical phraseology of the sixteenth century to become fixed.

Probably there were other reasons why Recorde's terminology in geometry failed to establish itself permanently. Some of his words carry an unpleasant sound to us and may have done so to his countrymen. At any rate, nineteen years after the issue of the *Pathway to Knowledg*, Billingsley uses in his *Euclid* (1570) the term "long square" for rectangle, "Diamond figure," or "diamonde" as an alternate for rhombus, but otherwise he makes no use of the terms given by Recorde; Billingsley does not speak of "prickes," "tweylike triangles," "gemowe lynes," and "like-jammys."

A distant approach to our linear continuum is found in the following Recordian sentences: "Nowe of a great numbere of these prickes, is made a Lyne, as you may perceiue by this forme ensuyng. where as I have set a numbere of prickes, so if you with your pen will set in more other prickes betweene euerye two of these, then wil it be a lyne, as here you may see — and this *lyne* is called of Geometricians, *Lengthe withoute breath*." This exposition is referred to as one of "theyr theorikes (which ar only mind workes)."

In *The Pathway to Knowledg* Recorde gave, besides definitions, 46 constructions, called "conclusyons," Euclid's postulates and axioms ("certaine grauntable requestes" and "certayn common sentences manifest to sence") and finally 77 theorems: "I go on with the theoremes, whiche I do only by examples declae, minding to reserue the proofes to a peculiar boke which I will then set forth, when I perceaue this to be thankfully taken of the readers of it."

Of historical interest are some of the technical terms in Recorde's *Whetstone of Witte*, for they indicate the migration of algebra from country to country. The name "Cossike numbers" for numbers represented by algebraic signs is evidently borrowed from German authors (Christoff Rudolff, Michael Stifel, Johann Scheubel and others) who spoke of "Cossische Zahlen" and sometimes called Algebra, "Die Coss." This German terminology in its turn is an adaptation from the Italian word "cosa" (thing) which was used by the Monk Luca Pacioli (1494) and by others, to designate the first power of an unknown

quantity. As the German 'Coss' and the Italian "Cosa" sound much like the Latin word "Cos" (whetstone), it was conjectured by A. DeMorgan* that Recorde's *Whetstone of Witte* was a punning title. It may seem ungracious to spoil an interpretation so ingenious but our recent study of Recorde has led us to the conclusion that Recorde did not cultivate the fine art of punning but indulged in less subtle literary forms, revelling in such pictorial language for the title-pages of his books as *Castle of Knowledge* (astronomy), *Grovnd of Artes* (arithmetic), *Pathway to Knowledge* (geometry). The phrase "whette stone of witte" was not freshly coined by him especially for his book on algebra; it was used by him in a more general sense on earlier occasions. In the *Epistle to the Kings M. A.*, printed in his *Pathway to Knowledge*, he speaks of "wyttie men" who "by the reasyng of wyttie artes (whiche be as the whette stones of witte)" may "increase more and more in wysedome." There is no particular and exclusive reference here to algebra or "Coss." *Apparently, when he wrote his algebra, he seized upon one of his habitual phrases, the "whetstone of witte" as a fitting title for that book.

Another word which found its way from Italy to Germany and thence to England is "cento," used by Pacioli and others to indicate the square of an unknown number, *i. e.*, x^2 . For the purpose of imitating the Italian sound of the word, the Germans changed the "c" to "z." Some German authors used the latinized form "zensus" to designate x^2 , and adopted the abbreviation "z." Thus, $15.z$ stood for $15x^2$; $10.zz$ for $10x^4$; moreover, \sqrt{zz} stood for "fourth root." This symbolism passed to England and was employed by Recorde. Hence we see that the Italian "cento" became the German "zensus" and the English "Zenzike." Says Recorde: "You shal vnderstande, that many men doe euer more call square nombres *zenzikes*, as a shorter and apter name." Similarly, Recorde writes "zenzizenzike" for the fourth power, "zenzicubike" for the sixth, "zenzizenzizenzike" for the eighth, "zenzizenzicubike" for the twelfth.

He was the first Englishman to use the German symbols + and —. As is well known, Recorde invented our sign for equality.

* A. DeMorgan, *Arithmetical Books*, London, 1847, p. 21.

"I will sette as I doe often in woorke vse, a paire of paralleles, or Gemowe lines of one lengthe, thus: ===== , bicause noe. 2. thynges, can be moare equalle." It is interesting to observe that this sign of equality is the only new symbol suggested by Recorde, but that one was so well selected, that mathematicians have been unwilling to let it die. In fact, no less influential a writer than Descartes endeavored to introduce another sign, but failed in his attempt. The history of mathematics shows many algebraists who suggested new symbols but failed to have any of them permanently incorporated into the science. Recorde's success in this matter was unique. In view of the fact that Recorde in all sincerity explains the origin of the sign of equality, it seems bad judgment for Charles Henry* to endeavor to establish its origin in the parallel strokes, sometimes found in medieval manuscripts, to represent *id est*.

DeMorgan has pointed out that in the *Castle of Knowledge* Recorde mentions the "arte of *sines* and *cordes*" which is the first time we have found the word "sine" in English.

Recorde cannot be said to stand out in the history of mathematics as a conspicuously creative mind. No great contribution on a level with the Italian solution of cubic equations or the Dutch invention of decimal fractions or the Vietian method of approximation to the roots of numerical equations or the clearer interpretation of negative and imaginary numbers or the recognition of new theorems in the theory of equations, stands to his credit. Only minor entries can be made on the credit side of his account, such as a simplified presentation of the solution of linear and quadratic equations. On cubic equations he says nothing. In most respects Recorde's exposition is along traditional lines. Perhaps the most signal example of this is his nomenclature in connection with ratios. The Greek Nicomachus, probably known to Recorde through the arithmetic of Boethius, had shown in his arithmetic an extraordinary predilection for complicated words to designate simple ratios, such as $3/2$, $4/3$, $2/3$, etc. In imitation of this practice, Recorde calls the ratios $3/2$ sesquialtera, $4/3$ sesquitertia, $5/3$ superbipartiens tertia, $3/4$ suptripartiens quarta. Some seven pages are devoted to such names, first by recording the Latin names and next by discussing certain English equivalents.

* C. Henry in *Revue Archéologique*, N. S., Vol. 38, 1879, p. 5.

Recorde's texts are written in the form of a dialogue between Master and Scholar. He states his reason for doing so in his preface to the *Grovnnd of Artes*: "because I judge that to be the easiest way of instruction, when the Scholar may ask every doubt orderly, and the Master may answer to his questions plainly." Recorde indeed anticipates many of the difficulties a pupil will encounter. Frequently quoted is the following passage in the *Grovnnd of Artes*, which illustrates the occurrence of rhyming sentences in the body of the text, such as are seldom found in his later books:

"*Scholar*. And I to your authority, my wit doe subdue, whatsoever you say, I take it for true.

"*Master*. That is too much, and meet for no man to be believed in all things, without shewing of reason. Though I might of my Scholar some credence require, yet except I shew reason, I doe it not desire."

Reading his text, the modern reader infers that Recorde must have been an excellent teacher, as indeed he was, if we may trust his biographers. In his *Whetstone of Witte*, he solves a number of algebraic problems, of which the first was as follows:

"*Master*. Take this for the firste question. Alexander beyng asked how olde he was, I am .2. yeres elder (quod he) then Epheuw. Yea, saied Epheuw. And my father was as olde as we bothe, and .4. yeres moare. And my father hawying all those yeres, saied Alexander, was .96. yeres of age. I demaunde now of you, how olde was eche of them."

To this the Scholar replies humorously, "I praie you aunswere the question yourself, to teach me the forme."

The Master explains, then proceeds to a problem involving a question of debt, and remarks: "There is nothyng better then exercise, in attaynyng any kynde of knowledg." Then follow questions on the size of armies, the heights of walls, the number of "bricke," the division of an estate, etc. In one place the Scholar remarks, "Although the question seme harde, I see many tymes, that diligence maketh harde thynges easie, and therefore I will ~~attempt~~ the worke of it."

With Recorde a negative number is "absurde" and "expresseth lesse than naught"; nevertheless there are passages which indicate that he did not reject them. "Howbeit for ex-

amples sake, you maie woorke, as well with *Absurde* numbers, as with any other."

Great interest is shown at the present time in the history of science during the middle ages. Roger Bacon, in particular, is being studied with renewed zeal. It is worth while, therefore, to quote Recorde's remark touching the long mooted question of Bacon's invention of the telescope. In the preface to the *Pathway to Knowledge* he says:

"Great talke there is of a glasse that he made in Oxforde, in whiche men myght see thynges that were doon in other places, and that was iudged to be done by power or euyll spirites. But I knowe the reason of it to bee good and naturall, and to be wrought by geometrie (sythe perspective is a parte of it) and to stande as well with reason as to see your face in cōmon glasse."

And indeed "great talke there is" at the very present time, when the daily press brings news of a Baconian book written in cypher that is now being deciphered at the University of Pennsylvania and which appears to reveal that Roger Bacon in the thirteenth century really possessed a telescope and microscope. Our histories of physics assign the invention of these instruments to the beginning of the seventeenth century, but Recorde made the above remark at the middle of the sixteenth century.

Recorde referred to the telescope when he was indicating the applicability of geometry to science. He was convinced not only of the practical usefulness of arithmetic, algebra and geometry, but also of their value in training the mind. He quotes from Plato's *Republic* on these points. His convictions in this matter are brought out on the very title page of the *Whetstone of Witte*, which in closing we copy in full:

The whetstone
of witte,
whiche is the seconde parte of
Arithmetike: containyng the extrac-
tion of Rootes: The *Cossike* practise,
with the rule of *Equation*: and
the woorkes of *Surde*
Numbers.

Though many stones doe beare greate price,
The *whetstone* is for exersice.

As neadefull, and in woorke as straunge :
 Dulle thinges and harde it will so chaunge,
 And make them sharpe, to right good vse :
 All artesmen knowe, thei can not chuse,
 But vse his helpe : yet as men see,
 Noe sharpenesse semeth in it to bee.

The *grounde of artes* did brede this stone :
 His vse is greate, and moare then one.
 Here if you list your wittes to whette,
 Moche sharpenesse therby shall you gette.
 Dulle wittes hereby doe greatly mende,
 Sharpe wittes are fined to their fulle ende.
 Now proue, and praise, as you doe finde,
 And to your self be not vnkinde.

These Bookes are to bee solde, at
 the Weste doore of Poules,
 by Jhon Kyngstone.